

Key

Chapter 4 – Molarity & Molar Stoichiometry Practice Problems

1) Europium hexahydrate ($\text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$) is used to prepare fluorescent dye to visualize fingerprints on hard surfaces at crime scenes. The dye solution is made by dissolving 1.00 g $\text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$ in a volume of 800.0 mL.

a) Calculate the molarity of the solution.

Know
 $\text{mass} = 1.00 \text{ g } \text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$

$\text{solution} = 800.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.8000 \text{ L}$

want Molarity (M)
 $M = \frac{\text{mol solute}}{\text{liter of sol'n}}$ ← can use molar mass to determine
 ← can convert mL → L

molar mass = $\text{Eu} + 3(\text{Cl}) + 12(\text{H}) + 6(\text{O})$
 $= 151.966 \text{ g/mol} + 3(35.453 \text{ g/mol}) + 12(1.00794 \text{ g/mol}) + 6(15.999 \text{ g/mol}) = 366.414 \text{ g/mol}$

$1.00 \text{ g } \text{EuCl}_3 \cdot 6 \text{H}_2\text{O} \times \frac{1 \text{ mol}}{366.414 \text{ g}} = 0.00273 \text{ mol } \text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$

$M = \frac{0.00273 \text{ mol } \text{EuCl}_3 \cdot 6 \text{H}_2\text{O}}{0.8000 \text{ L solution}}$

$M = 0.00341 \text{ M } \text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$

b) What mass of $\text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$ is present in 65 mL of a 0.50 M solution?

Know
 $V = 65 \text{ mL sol'n}$
 $M = 0.50 \text{ mol/L of } \text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$

want mass (g) ← can use molar mass to convert moles to grams
 $\text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$

$65 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times 0.50 \text{ mol } \text{EuCl}_3 \cdot 6 \text{H}_2\text{O} \times \frac{366.414 \text{ g } \text{EuCl}_3 \cdot 6 \text{H}_2\text{O}}{1 \text{ mol}}$

$= 11.9 \text{ g} = 12 \text{ g } \text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$

c) How do you prepare 278 mL of a 0.34 M solution from the 0.50 M solution?

Know
 $V_d = 278 \text{ mL}$
 $M_d = 0.34 \text{ M}$
 $M_c = 0.50 \text{ M}$
 ↑ more concentrated
 same species in solution & changing concentration
 ∴ dilution problem
 $M_c V_c = M_d V_d$
 ↑ want

want preparation of solution using
 V_c

prepare by diluting 190 mL of 0.50 M $\text{EuCl}_3 \cdot 6 \text{H}_2\text{O}$ solution to a volume of 278 mL.

so $V_c = \frac{M_d V_d}{M_c} = \frac{(0.34 \text{ M})(278 \text{ mL})}{(0.50 \text{ M})} = 189.0 = 190 \text{ mL}$
 2 sig. figs

Need a balanced chemical equation so can use molar ratios

2) How many grams of $\text{Al}_2(\text{SO}_4)_3$ are needed to react with 85.0 mL of 0.0500 M $\text{Ba}(\text{OH})_2$?

Know

$$V_{\text{Ba}(\text{OH})_2} = 85.0 \text{ mL}$$

$$M_{\text{Ba}(\text{OH})_2} = \frac{0.0500 \text{ mol}}{\text{L}}$$



$$85.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.0500 \text{ mol Ba}(\text{OH})_2}{\text{L}} \times \frac{1 \text{ mol Al}_2(\text{SO}_4)_3}{3 \text{ mol Ba}(\text{OH})_2} \times \frac{342.150 \text{ g Al}_2(\text{SO}_4)_3}{1 \text{ mol}}$$

Want

mass (in g)
of $\text{Al}_2(\text{SO}_4)_3$

$\therefore$ need molar mass of $\text{Al}_2(\text{SO}_4)_3 =$

$$2(\text{Al}) + 3(\text{S}) + 12(\text{O}) =$$

$$2(26.982 \text{ g/mol}) + 3(32.066 \text{ g/mol}) + 12(15.999 \text{ g/mol}) = 182.160 \text{ g/mol}$$

$$= 342.150 \text{ g/mol Al}_2(\text{SO}_4)_3$$

3) A reaction is performed by adding 25.0 mL of 0.185 M Na_3PO_4 to 34.0 mL of 0.140 M $\text{Ca}(\text{NO}_3)_2$. Determine the percent yield if 0.300 grams of a precipitate are collected.

Know

$$\text{Na}_3\text{PO}_4$$

$$V = 25.0 \text{ mL}$$

$$M = \frac{0.185 \text{ mol}}{\text{L}}$$

$$\text{Ca}(\text{NO}_3)_2$$

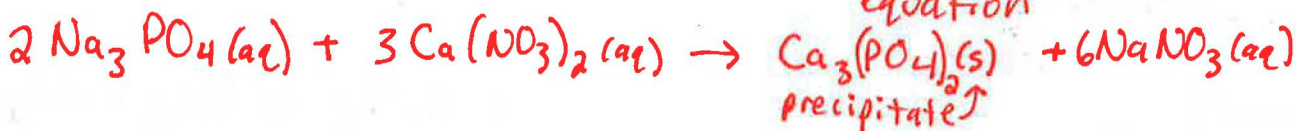
$$V = 34.0 \text{ mL}$$

$$M = \frac{0.140 \text{ mol}}{\text{L}}$$

precipitate

$$0.300 \text{ g}$$

need balanced chemical equation



Plan determine mass of precipitate formed by consuming all of reactant then " which is smaller amount (= limiting reagent)

$$25.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.185 \text{ mol Na}_3\text{PO}_4}{\text{L}} \times \frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{2 \text{ mol Na}_3\text{PO}_4} \times \frac{310.174 \text{ g Ca}_3(\text{PO}_4)_2}{1 \text{ mol}}$$

$$= 0.717 \text{ g Ca}_3(\text{PO}_4)_2 \therefore \text{Na}_3\text{PO}_4 \text{ is excess reagent}$$

$$34.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.140 \text{ mol Ca}(\text{NO}_3)_2}{\text{L}} \times \frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{3 \text{ mol Ca}(\text{NO}_3)_2} \times \frac{310.174 \text{ g Ca}_3(\text{PO}_4)_2}{1 \text{ mol}}$$

$$= 0.492 \text{ g Ca}_3(\text{PO}_4)_2 \therefore \text{Ca}(\text{NO}_3)_2 \text{ is limiting reagent so use this mass as theoretical yield}$$

Want

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \frac{0.300 \text{ g Ca}_3(\text{PO}_4)_2}{0.492 \text{ g Ca}_3(\text{PO}_4)_2} \times 100 = 60.97 = 61.0\%$$

↑
makes sense b/c > 30g

need to determine based on limiting reagent so need molar mass of

$$\text{precipitate} = 3(\text{Ca}) + 2(\text{P}) + 8(\text{O}) = 310.174 \text{ g/mol Ca}_3(\text{PO}_4)_2$$

$$= [3(40.078 \text{ g/mol})] + [2(30.974 \text{ g/mol})] + [8(15.999 \text{ g/mol})] = 310.174$$

yield
 $\text{Ca}_3(\text{PO}_4)_2$